weather would be improved if writers were given some training in the observations of weather forms and possessed some knowledge of weather causes. If writers will use, as needs they must, weather in amounts ranging from a modicum to a moiety in every outdoor scene, it is not improper to suggest seriously that meteorology, which is the science of weather, should have a place in the curriculum of *belles-lettres*.

Let no one be deceived by the notion that any meteorologist desires literary descriptions in the form of categorical scientific facts. The desire is rather otherwise—that good literature shall not be permeated by bad weather, but that, on the other hand, it shall be improved by the use of weather that simulates Nature—weather that appeals to him who knows what weathers are made up of. March winds are not always "raw," nor sunset skies always "imbued with a lurid glow." There are many phases of weather which, even if rare, have been occasionally witnessed by most persons and would be recognized if well described.

Again, meteorological metaphors are not undesirable, but, on the other hand, often facilitate the painting of a word picture in the most concise manner possible.

In Noah's flood "the fountains of the great deep were opened up and the windows of Heaven were opened." This tells briefly a story which would require many adjectives for an adequate description in a matter-of-fact way. Who has not been impressed with Nature's grandeur in the thunderstorm, when "with whipcords of lightning she drives the storm on." Here the metaphor is not strictly accurate, since in reality the storm generates the lightning; but the object of the metaphor is to create a true picture in the mind of the reader, and success is attained in a measure as the picture appears clean cut and correct, and the vehicle of the metaphor is forgotten.

In the use of better-defined weather types, accurate detail where detail is needed, and good metaphor where it will serve, as also in other ways, there are still opportunities for those who write to utilize weather descriptions that are not altogether trite and yet do no violence to Nature.

CLOUD NOMENCLATURE.[1]

By CHARLES F. BROOKS, Meteorologist.

Weather Bureau, Washington, D. C., Nov. 3, 1920.]

SYNOPSIS.

Cloud names closely defined are essential not only for the cloud observer but also for the cloud investigator. Since heights and the atmospheric processes responsible for particular clouds are not always known, the best basis for a nomenclature for general use is cloud appearance. The aspect of a cloud may be described in terms of form, coarseness, and density; and rather complete records can be made by recognizing the seven principal types of form, three degrees of coarseness, or apparent angular size, and five degrees of density. Such a system of keeping cloud observations is to be recommended only for those who have plenty of time and who wish to have great detail in their cloud records.

The general needs of meteorologists were recognized many years ago, as evidenced in the adoption of an International Classification of Clouds in 1896. This classification was simple and included aspects of form, coarseness, and density. Although the original classification was revised in 1905, the distinctions between several of the cloud forms were not closely drawn, and practically no provision was made for uniformity in detailed cloud records. As cloud forms occur in great variety the lack of names to indicate adequately the appearance of the sky has made cloud observations, in general, the least complete and the least accurate of any records of the important weather elements.

Pending further international revision an attempt is here made to provide for stricter differentiation of cloud forms, with the aid of a guide to identification. Particular emphasis is placed on the desirability of confining the name cirro-cumulus to ice clouds in order to prevent its present indiscriminate application to both the true, high cirro-cumulus and the appreciably lower, thin alto-cumulus. Differentiation of thin alto-stratus from cirro-stratus, and of nimbus from other rain clouds is also discussed. Revised wordings of parts of the International descriptions are suggested for consideration. Photographs* are not presented, for it is desired to place emphasis on the fact that the definitions form the ultimate basis for differentiation of forms.

The addition of 14 generally applicable subclasses, several of which already are widely used, to the present, simple International Classification is urged as an aid to greater detail and greater accuracy.

INTRODUCTION.

Cloud names are as necessary in the work of the meteorologist as rock names in that of the geologist or plant names in that of the botanist. To be widely serviceable, a system should invariably use the same name for the same kind of cloud and offer a sufficient variety of names adequately to describe the appearance of the sky. International agreement has already provided a fundamental nomenclature. As now used, however, different observers have various conceptions of the given types; and there is no uniformity in adding adjectives for describing certain cloud forms accurately.

CLOUD-APPEARANCE THE BASIS FOR CLASSIFICATION.

As a background for a discussion of the existing International Classification let us consider how cloud observations might be recorded were there no existent nomenclature and were there ample time at an observer's disposal. We are interested primarily in clouds as indicators of winds aloft, of atmospheric processes, and of future weather, and in clouds as sky cover affecting incoming and outgoing radiation. Horizontal movement and sky cover are recorded separately and are only in a minor degree involved in cloud form. But the name of a cloud should, if possible, give some indication of the atmospheric processes probably responsible for it, and also provide at least a partial basis for local forecast studies.

It would appear, then, that our classification of clouds should be based on cloud-forming processes. But how is one to know what processes are involved without being acquainted with the actual conditions in and about a particular cloud? A knowledge of meteorology, coupled with close observation of a cloud, may or may not provide unmistakable evidence of why there is a cloud and why it has such an appearance. Therefore, a classification by origin would be on an unsafe basis, especially since all observers do not study clouds with equal care nor interpret clouds alike, and since it should be possible to make a record without protracted observation. This leaves *appearance*, with, of course, all its indications as to height and origin, as the only safe and universal basis for cloud classification.

Form, coarseness, and density.—Cloud appearance may be described in terms of form, coarseness, and density. Since coarseness, or the apparent size of the elements and markings of a cloud, and density are matters of degree only, the primary differentiation of clouds must be based on form. The principal types of form to be seen

[1] Revised from paper presented at the meeting of the American Meteorological Society, Washington, D. C., April 22, 1920.

*A chart with 32 cloud photographs with legends conforming with this discussion will soon be issued by the U. S. Weather Bureau.

individually or in combination in clouds may be conveniently grouped in seven divisions, as follows:

1. *Fibrous*, characteristic of streaks of falling snow or rain as seen from a distance.

2. *Smooth*, characteristic of *sheetlike* clouds, especially when low, and when snow or rain is falling rather uniformly.

3. *Flocculent*, scaly, ice-cake like, or disk like, cloud elements in groups, which as wholes usually have smooth, curving outlines, which may be called *lenticuloid*, more or less lens- or lentil-shaped. When these curved outlines are markedly developed, and the clouds have the form of detached convex lenses, they are called "lenticular."

4. *Waved* or in *rolls*, characteristic of wave movements at or near horizontal boundaries between differing winds, or near the ground, and of lines where the wind at any level shifts to a new direction.

5. *Round-top*, characteristic of the summits of locally rising air masses.

6. *Down-bulged* or *round-holed*, characteristic of localized down-currents.

7. *Ragged*, characteristic of forming or evaporating cloud in a turbulent wind.

Any cloud defined in terms of form will have its aspect rather fully recorded, when the apparent size of each of its elements and markings, say, in such terms as *coarse*, *medium*, and *fine*, and when its density in such terms as *transparent*, *semitransparent*, *medium*, *dense*, and *very dense*, are noted. Thus, with seven names for form, with three degrees of coarseness, and five of density, we have an easily applied, compact, and, may I say, complete, basis for recording cloud appearance.

Experiment with cloud-recording in great detail.—Such a method of recording cloud observations was tried for 50 days, and was then abandoned, because (1) it was very time-consuming, even though requiring little thought or judgment; (2) the records were comparable only with difficulty, even though the mass of detail was in orderly form and in a relatively small compass; and (3) such a great number of combinations (about 3,000) were possible, that it was hopeless to devise satisfactory names for distinguishing one combination of detailed characteristics from another. As this strictly rational plan is impracticable for general use, let us consider the International Classification with the hope of modifying it to meet the need for greater explicitness and more detail, yet without departing from its fundamental and necessary simplicity.

THE INTERNATIONAL CLASSIFICATION.

History.—The following account of changes in the cloud nomenclature in general use since Howard, is quoted from (p. 317) in H. Helm Clayton's exhaustive chapter, a "Historical sketch of cloud nomenclature." [2]

> Notwithstanding the numerous proposed systems of cloud nomenclature, none has to any extent displaced the system of Howard [1803], which gradually came into general use. Here a name like *fracto-cumulus* has been borrowed from Poëy [1865–79], there the name of mammato-cumulus has been taken from Ley [1879–83], and *cumulo-nimbus* from Weilbach [1880]; but in the main the system of Howard has remained unchanged except by natural growth. The International system of Hildebrandsson and Abercromby [1887] is, as stated by the authors, only an adaptation for general use of the cloud names which had already come into use in different places by gradual and slight changes in the system of Howard. Kaemtz [1831–36] added the name *strato-cumulus*, thus distinguishing a cloud form recorded by other observers with [as] cumulo-stratus. Renou [before 1877] added the name *alto-cumulus* to distinguish the low form of cirro-cumulus, or a cloud intermediate between cirro-cumulus and strato-cumulus. In Portugal the name *strato-cirrus* came into use to describe the lowest form of cirro-stratus, or rather a lower bluish or grayish sheet which had previously been recorded as cirro-stratus. It appears to correspond to Poëy's pallio-cirrus, and was given the name *alto-stratus* probably by Hildebrandsson [1887].[3]

The International Classification of Clouds was formed largely from the most widely used cloud names and definitions at the time of its compilation some 30 years ago. It was, necessarily, an agglomeration and a compromise. Clayton quotes an account [4] of how Abercromby obtained photographs of clouds all over the world and then went to Upsala to see Hildebrandsson. Of this conference Abercromby himself, writes:

> My primary idea—in which Prof. Hildebrandsson entirely concurred—was that the name of a cloud is of far less importance than that the same name should be applied to the same cloud by all observers; and also that the existing names should be retained, only that the form they are applied to should be more precisely defined.[5]

Existing cloud schemes, of which there were many in use in different countries, were worked over. Abercromby continues:

> Eventually, we agreed that 10 terms, all compounded of Howard's 4 fundamental types—*cirrus*, *stratus*, *cumulus*, *nimbus*—would fully meet the requirements of practical meteorology, with the least disturbance of existing systems * * *.

Hildebrandsson's statement about this system is quoted (p. 300) as follows:

> If one wishes to study the connection between cloud forms and the phenomena of the atmosphere, or to use these forms for prognostication, he must have a detailed terminology. * * * According to my view the next most important purpose of cloud observations is to determine the wind directions at different heights of the atmosphere. For that purpose it is not necessary to distinguish so many forms.

An atlas based on the Hildebrandsson-Abercromby system was published. The International Meterological Congress at Munich, in 1891, adopted this system as the International Classification.

Outline of the International Classification, adopted in 1891.[6]—

(*a*) Detached clouds with rounded upper outlines (most frequent in dry weather).

(*b*) Clouds of great horizontal extent suggesting a layer or sheet (suggestion of wet weather).

A. Upper Clouds: Average altitude, 9,000 metres (30,000 feet).

(*a*) 1. Cirrus.

(*b*) 2. Cirro-stratus.

B. Intermediate Clouds: Between 3,000 metres and 7,000 metres (10,000 feet and 23,000 feet).

(*a*) 3. Cirro-cumulus.
(*a*) 4. Alto-cumulus.

(*b*) 5. Alto-stratus.

C. Lower Clouds: Below 2,000 metres (7,000 feet).

(*a*) 6. Strato-cumulus.

(*b*) 7. Nimbus.

D. Clouds of diurnal ascending currents.

(*a*) 8. Cumulus: top, 1,800 metres (6,000 feet); base, 1,400 metres (4,500 feet).

(*b*) 9. Cumulo-nimbus: top, 3,000 metres to 8,000 metres (10,000 feet to 26,000 feet); base, 1,400 metres (4,500 feet).

E. High Fogs under 1,000 metres (3,300 feet).

10. Stratus.

N. B.—The equivalents in feet of the heights given in metres are only roughly approximate.

The definitions and descriptions of each form as adopted were translated into English in 1894, and were published

[2] "Discussion of the cloud observations," Ann. Astr. Obs. Harvard Coll., 1896, vol. 30, pt. 4, pp. 271–500, 17 pl., 4to., Historical chapter, pp. 279–331. Cf. summary of intermediate length in Am. Met'l Jour., July, 1894, 11: 83–96.

[3] The use of *alto-stratus* was broadened in 1905 enough to include the nonfibrous sheet-clouds at intermediate heights, although these are not specifically mentioned.

[4] Op. cit., p. 299: Abercromby, R., Suggestions for an international nomenclature of clouds, Quart. Jour. Roy. Met'l Soc., 1887, 13: 154–162, discussion 162–166, plate. This and an earlier paper, ibid., pp. 140–146, contain an illuminating discussion of the way in which descriptive names of clouds became associated with considerations of altitude and attendant weather phenomena.

[5] Quart. Jour. Roy. Meteorological Soc., Apr., 1887, pp. 148–162; quoted in Clayton, op. cit., p. 299.

[6] Quoted from "Cloud forms according to the International Classification." British Meteorological Office, London, 1918, M. O. 233, 10 pp., 17 pl. [from photographs by G. A. Clarke].

in the first edition of the International Cloud Atlas in 1895. Slight revisions were made at the International Meteorological Conference at Innsbruck, in 1905, and published in the International Cloud Atlas, second edition, in 1910.[7]

General remarks on cloud observing under the International Classification.—Most meteorologists have at one time or another made cloud records. Some have tried to use them. In making cloud records it is seldom easy to decide on the appropriate cloud names for the appearance of the sky; and, when the decision is made, one feels almost invariably that another observer might have made a different record. Anyone who thinks of using these cloud records recognizes that, unless made with special reference to certain features, they can be relied on only in a very general way as data in any investigation. This situation is not necessarily the fault of the observer, for in spite of careful study, perhaps memorization of the definitions of the 10 cloud forms, one can not describe the sky by using these 10 names without elaborating remarks, and, since only an enthusiast would be expected to make such elaborating remarks, the observer is likely to consider the attainment of accuracy in cloud observation as well-nigh hopeless and, therefore, not worth more than a minute or two during the limited observation period. When a given cloud might be called any one of three names, few care to split hairs in deciding which it shall be.

This situation may be improved, however, for, once granted that the 10 names are to cover *all* observed cloud forms, we are faced merely with the duty of defining where the dividing line shall be placed between the forms where they converge. To be sure, if some changes in the wordings of definitions and descriptions will remove ambiguity and make them inclusive to their limits, the presentation of such modifications is justifiable. Any such attempts to clarify, however, should rest on ideas rather generally held among cloud observers, as indicated by remarks on this subject published in various countries. The following definitions and descriptions, quoted from the International Cloud Atlas, second edition,[8] are approached, therefore, with the idea of delimiting the application of each name in accordance with accepted usage, and for some, to suggest such broadening or altering of definitions as appear to remove ambiguities and to make them inclusive yet explicit:

1. **Cirrus** (Ci.).—*Detached clouds of delicate and fibrous appearance, often showing a feather-like structure, generally of a whitish colour.* Cirrus clouds take the most varied shapes, such as isolated tufts, thin filaments on a blue sky, threads spreading out in the form of feathers, curved [or straight] filaments ending in tufts, sometimes called *Cirrus uncinus*, etc.; they are sometimes arranged in parallel belts which cross a portion of the sky in a great circle, and by an effect of perspective appear to converge towards a point on the horizon, or, if sufficiently extended, towards the opposite point also. (Ci.-St. and Ci.-Cu., etc., are also sometimes arranged in similar bands.)

The distinguishing characteristics of Cirrus are that it is *fibrous* and *detached*. Although cirrus clouds are usually high, the actual or apparent height is not involved in differentiating Ci. from other cloud forms.

2. **Cirro-stratus** (Ci.-St.).—*A thin, whitish sheet of clouds* sometimes covering the sky completely and giving it only a milky appearance (it is then called *Cirronebula*), at other times presenting, more or less distinctly, a formation like a tangled web. This sheet often produces halos around the sun and moon.

Cirro-stratus is generally distinguishable from alto-stratus and stratus by its thinness, whiteness, and by halos when present. Difficulty arises, however, in differentiating Ci.St.[9] from thin A.St. or thin St. when the latter are brilliantly illuminated by the sun or moon and within an angular distance of 90° of the luminary. Under such conditions slow change of form and density and, usually, relatively slow movement, characteristic of high clouds, identifies a thin, white cloud sheet as Ci.St. Thus, while Ci.St. is "*a thin, whitish sheet of clouds*," all thin, whitish sheets are not Ci.St.

Although the 10 forms are classified in an introductory section of the International Cloud Atlas according to their average heights,[10] should we allow height to be a criterion on which to base records of cloud form? In cold, winter weather a nebulous white sheet at a low elevation, perhaps even reaching the ground, may produce brilliant halos. Should it not be called Ci.St.? It certainly fits the definition of no other form. Furthermore, on blustery days with the temperature near freezing and with heavy ragged St.Cu. covering much of the sky, what should we call the thin, more or less irregular veil of snow—falling from these St.Cu.—which shuts out the clear blueness of the sky between the dense cloud masses? The snowflakes are too irregular and too varied in orientation to produce halos. There is a "thin, whitish sheet of clouds" undoubtedly composed of ice particles, as all cirriform clouds are; surely it is not the foglike stratus, nor a forming nor evaporating alto-stratus ("a thick sheet of a grey or bluish colour"), therefore it must be called Ci.St. if any name at all is applied to it. And if it is not named or otherwise mentioned, an important feature of the sky-aspect is omitted from the cloud record. It is fortunate that height is not stipulated in the International *definition* of cloud forms.

3. **Cirro-cumulus** (Ci.-Cu.), **Mackerel Sky.**—*Small globular masses or white flakes without shadows, or showing very slight shadows, arranged in groups and often in lines.*

Although some critics claim that cirro-cumulus clouds are neither cirrus nor cumulus, this comment is a relic of the time when *cirro-cumulus* included both our present Ci.Cu. and A.Cu. Clayton (pp. 293–294) quotes Clement Ley as follows:

They are, in fact, neither in appearance, nor in mode of physical formation, either compounds of cirrus with cumulus, or hybrids between cirrus and cumulus. Therefore, in practice, the use of the word "cirro-cumulus" has led to a large number of clouds of no great elevation being classed amongst the cirriforms; a result which was of little consequence when the laws regulating the upper currents of the atmosphere had received no examination, but which must prove absolutely fatal to a

[7] Paris, 1910, 4°, English section, pp. 9–16, 29 figs.
[The pictures in this atlas, and the way they are named as well as the definitions and elaborating remarks on cloud forms and their observation, have been subject to considerable criticism. See especially: J. Vincent, Notes bibliographiques sur les Nuages, Ann. Météorologique, 1912, Obs. Roy. de Belg., pp. 262–271; and C. J. P. Cave, The forms of clouds, Quart. Jour. Roy. Meteorological Soc., 1917, vol. 43, pp. 61–81.]

Important cloud atlases published since 1910 are as follows:
Loisel, Julien, Atlas photographique des nuages. Paris, 1911. 20 very good photographs. [A review by J. Vincent, 1912, loc. cit., states that this atlas is of great service to new men, and that it imposes on official organizations, international or otherwise, the revision of the clouds of the intermediate level.]
Taffara, Luigi, Le nubi. Part I, Testo: 67 pp., diagrs., ills. Part II, Atlante [26 pls.] R. Ufficio Centrale di Meteorol. e Geodinamica, Rome, 1917. 14 by 9½ inches.
[Comprises discussion of cloud photography, a history of cloud nomenclature, and a new detailed classification by the author, all types of which are illustrated in the plates, largely from the author's photographs. See review by R. DeC. Ward, in *Geogr. Rev.*, Oct., 1920, 10:276, and by D. Brunt in Quart. Jour. Roy. Meteorological Soc., July, 1919, vol. 45, pp. 258–259.]
[Clarke, G. A.] Naval meteorological service cloud atlas. Prepared by Hydrographic Department, Admiralty, under the superintendence of Rear Admiral J. F. Parry. [London] 1918. p. 1, 14 col. plates. 48½ by 39 cm. [Large colored prints of oil paintings by G. A. Clarke.]

[8] The booklet, M. O. 233, loc. cit., contains another set of definitions, now in official use by British observers. The following note explains:
"The translation into English has been altered in certain respects from that which appears in the English version of the introduction to the International Cloud Atlas in order to represent more closely the original French."
Since the English version in the International Cloud Atlas is official, there seems to be no call for American observers to use a translation of the French version. At any rate, the British Meteorological Office translation of the French version does not differ appreciably from that in the International Cloud Atlas.

[9] In U. S. Weather Bureau practice, hyphens are omitted from the cloud-name abbreviations.
It would be still simpler, and more saving of time and space to use the old Signa Corps abbreviations: C for cirrus; K for cumulus; N for nimbus, and S for stratus.—*General Instructions to Observers of the Signal Service*, 1887, pp. 55–56. These abbreviations are still in use at Blue Hill Observatory.

[10] See outline quoted on p. 514, above.

scheme based upon those laws, according to which new and most valuable results will be attained. The name "cirro-stratus" is almost equally objectionable, and for similar reasons.

Meteorologists soon sought to escape this trouble by giving the names *alto-cumulus* and *alto-stratus*, respectively, to the lower forms of the clouds formerly called "cirro-cumulus" and "cirro-stratus." In doing so, however, it was deemed sufficient merely to define Ci.Cu. as "small globular masses," etc., to distinguish it from A.Cu. which was defined as "Largish globular masses," etc. Unfortunately for the value of this distinction, however, forming A.Cu. often satifies exactly every point in the definition of Ci.Cu., and, therefore, is called Ci.Cu. We now know, what was apparently not known then, that the higher, true Ci.Cu. are invariably formed of ice, while the lower group, for which the name A.Cu. was exclusively intended, are usually composed in large part, at least, of water droplets. Distinguished on the basis of ice-crystal or water-droplet, Ci.Cu. and A.Cu. are not likely to be confused; the former can make no diffraction colors, corona, or irisation, in the vicinity of the sun or moon,[11] while the latter especially when so thin as to be commonly mistaken for Ci.Cu. on account of its fine structure (suggestive of great height), will produce brilliant diffraction colors. The fact that halos are not seen in Ci.Cu. is not a valid objection to the claim that they are of ice crystals,[12] for the lack of halo phenomena is a necessary consequence of the turbulence and unequal size of the crystals attending, respectively, the diverse vertical motions and the process of condensation responsible for the Ci.Cu.

Ci.Cu. is defined as "small." What should we call the rounded tops on cirrus tufts, when of medium or large size which top the Ci.St. and fibrous A.St. clouds overflowing from an intense cyclone? Although these are of snowflakes, like Ci.Cu., they seem to fit better the definition of A.Cu.

In view of these considerations, it would seem advisable to have the definition and description of Ci.Cu. read:

Cirro-cumulus (Ci.Cu.).—*Small white flakes or tenuous globular masses which produce no diffraction colors near the sun or moon.* The cloud units are usually arranged in groups and often in lines, suggestive of one or more sets of small waves. Ci.Cu. being composed of ice particles, are usually bright, in spite of their tenuity, and do not have the solid appearance characteristic of liquid-droplet, A.Cu. clouds. At times the tops of cirrus tufts or of Ci.St. sheets are capped with Ci.Cu."

4. **Alto-stratus** (A.-St.).—*A thick sheet of a grey or bluish colour*, sometimes forming a compact mass of dark grey colour and fibrous structure. At other times the sheet is thin, resembling thick Ci.-St., and through it the Sun or the Moon may be seen dimly gleaming as through ground glass. This form exhibits all changes peculiar to Ci.-St., but from measurements its average altitude is found to be about one half that of Ci.-St.

Differentiating A.St. from Ci.St. presents the same difficulties as the distinction between A.Cu. and Ci.Cu just discussed. Although the name *alto-stratus* was invented for the purpose of differentiating the lower section of the old cirro-stratus group from the upper, the International definition and description fails to provide adequately for this. Like A.Cu., it is described as a heavier cloud, which at times looks like its higher counterpart. In addition, however, the lower altitude of A.St. is mentioned. Thin A.St. is very commonly mistaken for Ci.St., and in much the same way that A.Cu. is mistaken for Ci.Cu.; the thin A.St. satisfies every point in the definition of Ci.St. Here, as in the case of A.Cu. versus Ci.Cu., the lower form can be identified by its more or less smoky appearance when more than 90° from the sun, and, often, by the changeable form and density of particular sections of the sheet, and by its production of coronas. The fibrous A.St., which is of snow, as is Ci.St., is merely a dense cloud, which if thinner would be Ci.St. Thus, fibrous A.St. is to be distinguished from Ci.St. by greyness, and, in case a halo has previously been seen with thickening Ci.St., by the disappearance of the halo (on account of the weakening of the light passing through the cloud, not because of any decreased refraction).

Other cloud observers have complained about the inadequacy of the definition of A.St. to meet the original intention of dividing the old "cirro-stratus" into upper and lower sections—the new Ci.St. and A.St. Thus, J. Vincent[13] objects to the incompleteness of the A.St. definition arising from the omission of any mention of nonfibrous A.St. and of those features of it, such as undulations and mammato forms, so commonly observed. Would not some such definition and description of A.St. as the following be more serviceable than the present International one?

Alto-stratus (A.St.).—*A sheet of grey or bluish color*, either generally fibrous or presenting a smooth, undulated, mammato, or frayed-hole appearance. Through the fibrous (snow-crystal) A.St. the sun or the moon may at times be seen dimly gleaming as through ground glass. On thin parts of the other (water droplet) kind diffraction colors appear in the vicinity of the sun or moon. Steady rain or snow may fall for hours from A.St.[14]

5. **Alto-cumulus** (A.-Cu.), **Great Waves.**—*Largish globular masses, white or greyish, partially shaded, arranged in groups or lines, and often so closely packed that their edges appear confused.* The detached masses are generally larger and more compact (resembling St.-Cu.) at the center of the group, but the thickness of the layer varies. At times the masses spread themselves out and assume the appearance of small waves or thin slightly curved plates. At the margin they form into finer flakes (resembling Ci.-Cu.). They often spread themselves out in lines in one or two directions.

A.Cu., especially when just forming and when higher clouds are absent, may apparently satisfy every point in the definition of Ci.Cu. Such A.Cu., however, usually has a solid appearance, not characteristic of Ci.Cu., and presents brilliant diffraction of colors in the vicinity of the sun or moon. Furthermore, thicker, shadowy parts of the same formation are usually present in other parts of the sky or develop within an hour or two. In view of what so often presents itself as undoubtedly A.Cu., why not reword the definition and description as follows: "Alto-cumulus (A.Cu.).—*Globular, scaly, or wave-like masses, white or greyish, partially shaded*, usually arranged in groups or lines, and often so closely packed that their edges appear confused. In the vicinity of the sun or moon diffraction colors are usually visible. At times the tops of large cirrus tufts or of Ci.St. or A.St. masses are capped with rounded domes of A.Cu., too large to be called Ci.Cu."

[11] The two parts of such a statement as the following are incompatible: "They [Ci. Cu are all composed of ice dust or crystals and may be prismatically colored when near the sun (Irisation)."—A. G. W. Howard, "The Clouds," on back of Aug., 1920, issue of monthly meteorological charts of the East Indian Seas, published by Brit. Met. Off. For discussion of this question of optics see p. 528-537 in W. J. Humphreys "Physics of the Air," Philadelphia, 1920.

[12] Cf. "It would appear that true cirro-cumulus is not composed of ice particles, for halos are not seen in these clouds . . ."—C. J. P. Cave. The forms of clouds, Quart. Jour. Roy. Meteorological Soc., 1917, vol. 43, pp. 61-82, 27 figs. (Quotation from p. 65.)

[13] Loc. cit. (footnote 7 above), p. 266.

[14] J. Vincent cites the omission of a mention of this fact as a reason for the widespread use of the synonym "rain-clouds" for "nimbus" (ibid.).

Clayton gave the name *alto-nimbus* to A. St. from which rain or snow is falling; and this is still in use at Blue Hill Observatory (Massachusetts).

The more or less confusing descriptive matter of the International text can then be omitted. A comparison with the definitions of St.Cu. and Ci.Cu. would be sufficient to reveal the facts that large, dense A.Cu. borders on the smaller St.Cu., and that thin, small A.Cu. must resemble Ci.Cu. in most respects.

6. **Strato-cumulus** (St.-Cu.).—*Large globular masses or rolls of dark clouds often covering the whole sky, especially in winter.* Generally St.-Cu. presents the appearance of a grey layer irregularly broken up into masses of which the edge is often formed of smaller masses, often of wavy appearance resembling A.-Cu. Sometimes this cloud-form presents the characteristic appearance of great rolls arranged in parallel lines and pressed close up against one another. In their centres these rolls are of a dark colour. Blue sky may be seen through the intervening spaces which are of a much lighter colour. (Roll-cumulus in England, Wulst-cumulus in Germany.) St.-Cu. clouds may be distinguished from Nb. by their globular or rolled appearance, and by the fact that they are not generally associated with rain.

It is well, perhaps, to point out that some St.Cu., unless in very large units, would be called A.Cu. if viewed from a depth of, say, 2 kilometers below the earth's surface. Correspondingly, a cloud formation which might be called A.Cu. by an observer in a valley, may be called St.Cu. by one on a mountain 2 km. higher. For many cloud observers, St.Cu. forms a convenient catch-all for any dense cloud that can not readily be classified otherwise. It should be recognized, however, that there is no more justification for calling such a cloud St.Cu. than for calling it something else, unless its characteristics are more nearly like those of St.Cu. as defined than like those of any other form.

Since the word "globular" carries the implication of sphericity, it might be better to use the words "disk-like or scaly" instead. Then the distinction between detached St.Cu. with its generally flat tops and Cu. with its dome-shaped tops would be more obvious.

7. **Nimbus** (Nb.), **Rain Clouds.**—*A thick layer of dark clouds, without shape* and with ragged edges, from which *steady* rain or snow usually falls. Through the openings in these clouds an upper layer of Ci.-St. or A.-St. may be seen almost invariably. If a layer of Nb. separates up in a strong wind into shreds, or if small loose clouds are visible floating underneath a large Nb., the cloud may be described as *Fracto-nimbus* (Fr.-Nb.) ("Scud" of sailors).

The raggedness and density of Nb. differentiates it from the sheetlike St. All rain clouds are not nimbus, and even those clouds from which a steady rain or snow is falling are not nimbus unless ragged edges are visible. Furthermore, there may be "rainless nimbus."[15] With regard to the wording of the definition and description, the words "Rain clouds" at the beginning, carry to many observers the implication that all rain clouds are Nb. (if not Cu.Nb.). The first sentence gives the correct conception, therefore, I think the words "Rain clouds" should be omitted. The last sentence, describing Fr.Nb. seems unnecessary, and it detracts from the strength of the definition of Nb. It is somewhat incongruous to have nimbus as "A thick layer of dark clouds, without shape and with ragged edges," and then to describe (thin) separated wisps as "fracto-nimbus." "Fracto" has the implication of being broken or ragged: and since nimbus is a ragged cloud, fracto-nimbus is thus a ragged ragged cloud. It is probable that no rain (except perhaps a light drizzle) ever falls *from* a piece of scud—the rain falls *through* it.

There are, perhaps, three subtypes of nimbus. One occurs with moderate to brisk, converging southerly winds. Long lines of cloud parallel to the wind direction grow and grow from ragged, though nearly horizontal, bases near the ground and lean forward aloft. The tops of these convectional clouds are probably invariably rounded, but they are not often seen from below. The International Atlas says that when such rounded tops are visible the clouds may be called *Nimbus cumuliformis*. A second (uncommon) type of nimbus develops from heavy fibrous A.St., with a rather coarse mammato structure, which, by the time rain falls develops into very large ragged masses with curved lines still predominating. A third type of nimbus may best be described as the dense, formless clouds characteristic of showery spring or summer days; usually with some thunderstorms (in Cu.Nb.).

Although many observers claim that there should be no such cloud as Nb. and that "nimbus" be used merely as a substantive, (cf. Ley, loc. cit., p. 74) I am strongly in favor of its retention, for it comprises a rather definite type of cloud which otherwise would merely make worse the present potpourri St.Cu.

8. **Cumulus** (Cu.), **Wool pack Clouds.**—*Thick clouds of which the upper surface is dome-shaped and exhibits protuberances while the base is horizontal.* These clouds appear to be formed by a diurnal ascensional movement which is almost always noticeable. When the cloud is opposite the Sun, the surfaces facing the observer have a greater brilliance than the margins of the protuberances. Then the light falls aslant, as is usually the case, these clouds throw deep shadows; when, on the contrary, the clouds are on the same side of the observer as the Sun, they appear dark with bright edges.

True cumulus has well defined upper and lower limits, but in strong winds a broken cloud resembling Cumulus is often seen in which the detached portions undergo continual change. This form may be distinguished by the name *Fracto-cumulus* (Fr.-Cu.).

Cu. is easily recognizable by the fact that it is *domed* and *detached*. This applies to clouds even when rain is falling from them. The International Atlas provides for such the name *Cumulus nimbiformis*. When the Cu. clouds, such as are characteristic of clearing weather with a northerly wind on a bright morning after rain has fallen, reach a level of little or no lapse-rate, or possibly an inversion of temperature, and their domed tops flatten, and sometimes spread[16] the clouds then are to be called St.Cu. Under such conditions, the newly forming clouds have the domed tops, and are Cu., while the older ones have become St.Cu.

9. **Cumulo-nimbus** (Cu.-Nb.), **The Thunder-Cloud; Shower-Cloud.**—*Heavy masses of cloud rising in the form of mountains, turrets or anvils, generally surmounted by a sheet or screen of fibrous appearance (false Cirrus) and having at its base a mass of cloud similar to nimbus.* From the base local showers of rain or snow (occasionally of hail or soft hail) usually fall. Sometimes the upper edges assume the compact form of cumulus, and form massive peaks round which delicate "false Cirrus" floats. At other times the edges themselves separate into a fringe of filaments similar to Cirrus clouds. This last form is particularly common in spring showers.

The front of thunder-clouds of wide extent frequently presents the form of a large arc spread over a portion of a uniformly brighter sky.

Cu.Nb., in brief, is the massive, composite cloud, usually[17] with a fibrous [snow], spreading top. While it usually harbors a thunderstorm, the occurrence of thunder and lightning within it is not an essential characteristic. In the matter quoted from the International Atlas there seems to be no need for the introductory characterizations, "The Thunder-Cloud; Shower-Cloud." The descriptive matter covers this fact. Just as with nimbus, the isolated appearance of these descriptive names implies to some observers that all shower clouds are cumulo-nimbus. Therefore, I believe that "The Thunder-Cloud; Shower-Cloud," should be omitted. In view of the erroneous and ambiguous impression conveyed by the

[15] Cf. Clement Ley: Cloudland, p. 108.

[16] The spread top sheet in such a formation is still called *cumulo-stratus* by many European observers, although this name was eliminated from the International Classification because of the liklihood of confusion with St.Cu. Cf. A. de Quervain, Beiträge zur Wolkenkunde, Met. Zeitschr., 1908, 25:433-453 (ref. to p. 435).

[17] Cave would make it "always": loc. cit. p. 73.

words "false cirrus" applied in the first instance to clouds that are real Ci. or Ci.St., and in the second, to A.St. or Ci.St. scarfs, I believe that they should be omitted from the quoted matter above.[18] Furthermore, the definition and the sentence mentioning the occurrence of precipitation are sufficient to indicate what a Cu.Nb. cloud is. The last three sentences of the first paragraph seem to be extraneous and weaken the explicitness of the definition.

If this definition of cumulo-nimbus is to be followed, it is obvious from the following considerations that except under unusual circumstances the number of tenths of the sky covered by cumulo-nimbus can not be more than 3 or 4. When a Cu.Nb. cloud with a spreading top approaches the observer, is he to record, Cu.Nb. 1, Cu.Nb. 2, etc., till it covers the sky as Cu.Nb. 10? If so, the reader of the record, would have no idea of the appearance of the clouds except at the very start. On the other hand, if the observer after recording, say, Cu.Nb. 2, shifts to A.St. 4 and Nb. 1, we get an indication of what the clouds looked like, although unless we happen to find a record of thunder and lightning, or some explanatory notes, we may be misled into thinking that the Cu.Nb. cloud has disappeared.

10. **Stratus** (St.).—*A uniform layer of cloud resembling a fog but not resting on the ground.* When this sheet is broken up into irregular shreds in a wind, or by the summits of mountains, it may be distinguished by the name *Fracto-stratus* (Fr.-St.).

Of Stratus, Abercromby says:[19]

We now come to the second variety of clouds, to which the name of stratus is applied, because it always lies in a thin horizontal layer, like a stratum of rock or clay. Pure stratus has no sign of any hairy or threadlike structure except at the edges, for a stratum which shows much marking would be cirro-stratus, and has quite a different origin. Pure stratus is essentially a fine-weather cloud, and is especially characteristic of antityclones. One very beautiful variety is often seen during a fine night, then the cloud forms thin broken flakes, something like mackerel sky, from which, however, it is really quite distinct. In Howard's original work on clouds, "stratus" was applied to ground mist, but that idea is now entirely discarded by all meteorologists.

Stratus is the layer-cloud that closely hems in the sky. It is not necessarily uniform, however, and this characteristic, when present, is useless for differentiating St. from A.St. and Ci.St.[20] Neither do all St. clouds resemble a fog, as is evident from the Abercromby quotation, above. At times, St. forming by mixture on the nearly horizontal under-boundary of a relatively warm wind will present a mammillated or undulated appearance, or, if condensation takes place in the lower as well as in the upper wind, an aspect not unlike a ragged, inverted, choppy sea. The low height by which thin St. may be differentiated in questionable cases from A.St. or Ci.St. is evident from the visible motion within the cloud, and the usual rapid progress across the sky. Thin St. forms coronas about sun or moon, and at more than 90° from the sun or moon looks more or less smoky. *Lowness* and *flatness* are the essential characteristics of St., therefore, why not define it as "A low [21] layer of cloud"? and add, "St. is distinguishable from A.St. only by whether or not it appears to be lower than 1,000 meters above the surface."

In the sentence about Fr.St., the words "in a wind, or by the summits of mountains" are not only unnecessary, but preclude considering as Fr.St. ragged evaporating remnants or first-forming wisps of a St. cloud when there is practically no wind.

Fr.St. is indistinguishable from Fr.Cu., and Fr.Nb. except by its associations. In view of the fact that forms other than Cu., St., and Nb. have ragged aspects at times, it would seem best to abandon the limitation of "Fracto" to only three and recognize it as applicable to any cloud type.

TABULAR GUIDE TO CLOUD IDENTIFICATION.[22]

Bearing in mind the considerations brought forth in this discussion, the following tabular guide to cloud identification has been constructed. This guide is serviceable whenever an observer can describe a cloud or group of clouds at the same level in terms of form, coarseness and density.

Characteristics.	International cloud forms.									
	Ci.	Cl.St.	Ci.Cu.	A.St.	A.Cu.	St.Cu.	Nb.	Cu.	Cu.Nb.	St.
Fibrous	x								x[1]	[6]
Sheetlike	(*)	x[2]		x		x		(*)		x
Smooth	(*)		(*)			(*)		(*)		
Lenticuloid							(*)			
Flocculent	(*)	(*)	f	(*)	[f]m	c	(*)	(*)		fm[7]
Rolled	(*)	(*)		(*)		x	(*)	(*)		(*)
Undulated							(*)	(*)		
Round-top	(*)	(*)	f	(*)	[f]m[c[4]]	c		c[5]	c	(*)
Down-bulged										
Ragged							c		c	
DENSITY.	[*Usually all bright.*]			[*Gray or shadowy, at least locally.*]						
Nearly transparent										
Semitransparent										
Medium		(*)	(*)							
Dense	(*)	(*)	(*)							
Very dense	(*)	(*)	(*)							

Legend: f=fine, m=medium, c=coarse, in angular size as seen from the ground. x may have any angular size. Where one letter or group of letters appears twice under a single heading such a cloud-form has one or the other characteristic: and where there are different letters on separate lines it has one of the characteristics marked by letter as well as one marked by the other letter. Thus, St. Cu. has layer or roll structure, and also is either flocculent or round top. (*) indicates that the cloud named can not have such a characteristic.

A blank shows that the cloud may or may not have the indicated characteristic.

[1] Almost always fibrous top.
[2] Often with halo—no halo with any other form except Ci., and, rarely, Cu.Nb. top
[3] When fine, with diffraction colors when near sun or moon.
[4] Only when topping Ci., Cl.St., or A.St.
[5] Base horizontal.
[6] Fibrous only when like more or less interlaced fibrous bark cloth.
[7] Distinguishable from A.Cu. by lowness and sheet-like aspects of the formation as a whole.

[18] A. de Quervain, loc. cit., gives, on pp. 442-443, an historical account of "False Cirrus," essentially as follows:

"False Cirrus" came to be applied early apparently to the [scarf] cloud [see MO. WEATHER REV., July, 1917, 45: 361-3 3], and it has since been shifted to include both [scarfs] and the Cl.St. tops of Cu.Nb. In 1887, Köppen called attention to altitude measurements by Ekholm and Hagström which showed the altitude of "False Cirrus" to be 3,900 meters, 5 observations)—much lower than Ci. In 1889 (Met. Zeitschr., p. 443) Hildebrandsson gave the following definition: "When this cloud form is well-developed, it looks like sheet of Ci. or Ci.St. [Pseudo-cirri of the A.Cu. level or lower were not so carefully differentiated then as now.—A.de Q.], which sheet the great Cu. peak frequently pierces or forms itself into a cirriform sheet." Later Swedish observations showed Cl.St. tops at 6,600 meters average altitude, and 9,000 meters maximum. Nevertheless, "False Cirrus" is still generally considered to be low. The Potsdam observations of the International Cloud Year confused [scarfs] with Ci.St. tops, but those which were surely one or the other give the following averages and extremes:

[Scarfs] and caps: mean 4,140 m.; max., 6,470 m.; min., 2,890 m.
Cl.St. overflow tops: mean 7,120 m.; max. 9,400 m.; min. 6,290 m.
min. 2,900 m. (spring squall).

The name "False Cirrus" ought to come out of the International definition of Cu.Nb. Möller, 1890 and 1906, described the two forms, but explained them as owing to the same causes. Never does a Ci.St. top grow out of a cap (or scarf) form; though they may occur practically together and be intermingled.

Cave, loc. cit., p. 74, does not help to clarify the situation when he says that veil [scarf] cloud is to be differentiated from false cirrus.

J. Vincent, loc. cit., decries the addition of "False cirrus" as a characteristic of Cu.Nb, since Cu.Nb. is nothing other than a Cu. cloud that has made a great development, and since scarfs and snowing caps are not differentiated. He also complains of the use of "cumulus," in the name "mammato-cumulus" which surely is not cumulus, but usually is a feature of an A.St. cloud.

See also: Staikoff, St. D., Ueber die Natur der Gewittercirren, Met. Zeitschr., 1908, p. 361; Osthoff, H., Streifenwolken, ibid., 1907, p. 534; Kassner, C., Gewitterschirm und Sonnenringe, ibid., 1907, p. 301.

[19] "Weather," London, 1887, p. 82 (quoted by Clayton, pp. 324-325).

[20] Cf. Vincent, loc. cit.

[21] The omission of "low" from the International definition is deplored by A. de Quervain in his review of the International Atlas (Met. Zeitschr., 1912, pp. 189-190).

[22] There is "A guide to the identification of cloud forms," published in "The Observer's Handbook," Metl. Off., London, 1915, pp. XXXIV-XXXV. It is arranged after the manner of organization charts. There are three groups, headed "Clouds seen mostly in plan," "Clouds seen mostly in elevation or profile," and "Low clouds seen in plan or elevation according to circumstances."

USING THE INTERNATIONAL CLASSIFICATION FOR DETAILED OBSERVATIONS.

Is there not a way of using the International Classification so as to show details of cloud appearance to any extent needed? H. H. Clayton's detailed system has not been widely used because of its unwieldy Latin names.[23]

The most important of his subclasses; and a few new ones, however, can be given descriptive English adjectives or otherwise briefly described, and these can be designated in cloud records by exponential letters which are in many cases identical with those used by Clayton: *f* (ragged), *t* (thin), *n* (rain or snow falling from cloud, whether or not precipitation reaches the ground), *c* (part of, or derived from, thunderstorm cloud), *r* (roll cloud), *s* (smooth), *q* (very fine texture), *c* (tall relative to width), *l* (lenticuloid, i. e., with part or all bounding lines like the smooth curves of a lens),[24] *m* (mammillated), *u* (undulated), *b* (in bands or streaks), *z* (in zig-zags, or with marked angles in lines—fibrous clouds only), *d* (detached units—not needed with Ci. and Cu.).

Thus, St^{f} represents fracto-stratus; A.Cu.^{t} disk-like, or ice-cake form, alto-cumulus; A.St.^{sn} smooth alto-stratus from which rain or snow is falling.

The use of one, two, or three of the international names for different parts of the same cloud sheet, adds greatly to the possibility of expressing adequately the appearance of the clouds.

CONCLUSIONS.

1. Cloud-records to be comparable should be based on the appearance of the clouds as seen from the ground. If (as we can not) we could always know the origin of a cloud, a classification on the basis of origin would be preferable. The elements of cloud appearance may be recorded without naming cloud types; but for discussion names are necessary.

2. International agreement has provided a set of 10 cloud names to cover all cloud forms; but the definitions of these 10 do not include all cloud forms, nor do they differentiate them adequately. The chief sources of trouble are as between the following pairs: Ci.Cu. and A.Cu., Ci.St. and A.St., Nb. and other rain clouds, and, perhaps, St.Cu. and St. or A.St. If Ci.Cu. as defined is confined to ice-clouds, the frequent misnaming of A.Cu. will be eliminated. If it is generally understood that A.St. may be either a more or less dense fibrous, mammilated or smooth cloud of snowflakes, or a smooth, undulated, or mammilated water-droplet cloud, which is sometimes as thin and white as Ci.St., our difficulties on its score will be largely removed. If it is recognized that *nimbus* is the name of a cloud form, and not a synonym for the occurrence of precipitation, much further trouble will be prevented. Finally, if St.Cu. is always thought of as strato-*cumulus*, there will be less of the indiscriminate misnaming of irregular St. and A.St. With these and other difficulties removed it is possible to construct a tabular guide which will indicate which one of the 10 names to apply to any cloud that an observer can describe.

3. A vocabulary of 10 words, is, however, rather limited for recording and discussing the manifold aspects of the sky. The inadequacy of the language of some African tribes has contributed in no small degree to holding them at the bottom of the culture scale. On the other hand, the wide range of expression and shades of meaning allowed by the English language has been a decidedly favorable factor in the rise of English speaking peoples to their present position in the world. Let us adopt a set of standard characteristics, such as: Mammillated, ragged, undulated, etc. If, in addition, we make separate notation of density and actual, computed, or probable height, our cloud records will give a real indication of the aspect of the sky, and will thus complete the weather-picture provided by instruments, meteorographs, and pilot balloons.

ACKNOWLEDGMENT.

For months Mr. S. P. Fergusson has been giving me the benefit of his years of familiarity with the growth of the International Classification and with the detailed observing of clouds at Blue Hill Observatory. I wish to acknowledge gratefully his many suggestions, especially his service in checking tendencies to deviate too far from well-tried practice.

How to make and reduce detailed cloud observations and the use of a new form for cloud records will be presented in a later paper.

[23] Op. cit., pp. 332-349, ch. 2, "A new detailed nomenclature of clouds, founded on the International nomenclature." Clayton's reasons for proposing these new details were: That they were needed for exact scientific studies, for descriptions of special occurrences, for meteorological observatories where observations are made, and for the use of specialists. His basis was form, altitude, and origin, as compared with Howard's basis of form only, and the International basis of form and altitude (A.Cu. vs. Ci.Cu., A.St. vs. Ci.St.). Although Clayton mentions origin in the cases of Cu. and St., he offers no change in names in consequence. "As the knowledge of the causes of special cloud formations increases, however, increasing weight will no doubt be given to cloud origin in determining classification and nomenclature." With this, the classification becomes one of form and altitude, therefore, much of the chapter is devoted to cloud altitudes. He evolves a detailed system which may serve the specialist who has plenty of time in which to apply it, but the large number of special forms and their Latin names will always cause it to be avoided by all but a very few enthusiasts.

[24] Not usually applicable to Ci., Ci.Cu., A.Cu., St.Cu., Nb., Cu., or Cu.Nb. The use of the word *lenticular* with Ci.Cu. and A.Cu. is common, in spite of the fact that most lenticular clouds are A.St. (cf. J. Vincent, loc. cit.).

LAYER MEASUREMENTS OF SNOW ON GROUND NEAR SUMMIT, CALIF.

By H. F. ALPS and O. H. HAMMONDS.

[Weather Bureau, Reno, Nev., Oct. 9, 1920.]

The layer measurements were made in the open park, about one-fourth mile in a southeasterly direction from the railroad station at Summit, in the same place and in the same manner as during the preceding season. From our experience in this work during the past four seasons, it is believed that this park affords an ideal location for layer measurements of the snow cover.

Only four trips to the Summit were made, on account of the long interval between the first and second general storms in the mountains. The first measurement of the snow cover was made on December 31, 1919. At that time, the depth of the snow was 39 inches, and the ground was frozen to a depth of one inch. The top layer of the snow was slightly granular, due to surface melting. As the snowfall was light in January and the first half of February, the second trip was made on March 5, 1920, when the depth of snow on the ground was 68 inches. The old snow, the greater part of which fell in December, was 35 inches in depth with a 10-inch crust which would support any ordinary vehicle. This